



US009010611B2

(12) **United States Patent**
Ross et al.

(10) **Patent No.:** **US 9,010,611 B2**
(45) **Date of Patent:** ***Apr. 21, 2015**

(54) **END EFFECTOR IDENTIFICATION BY MECHANICAL FEATURES**

(71) Applicant: **Covidien LP**, Mansfield, MA (US)

(72) Inventors: **Adam Ross**, Prospect, CT (US);
Michael Zemlok, Prospect, CT (US);
Stanislaw Marczyk, Stratford, CT (US)

(73) Assignee: **Covidien LP**, Mansfield, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/282,724**

(22) Filed: **May 20, 2014**

(65) **Prior Publication Data**
US 2014/0252063 A1 Sep. 11, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/773,176, filed on May 4, 2010, now Pat. No. 8,733,614, and a continuation-in-part of application No. 12/345,167, filed on Dec. 29, 2008, now Pat. No. 7,815,090, which

(Continued)

(51) **Int. Cl.**
A61B 17/04 (2006.01)
A61B 17/10 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **A61B 17/068** (2013.01); **A61B 17/07207** (2013.01); **A61B 2017/00017** (2013.01); **A61B 2017/00398** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC A61B 17/068; A61B 2017/00017; A61B 2017/00398; A61B 2017/2927; A61B 6/588
USPC 227/175-182.1
IPC ... A61B 17/68, 2017/17, 2017/398, 2017/2927, A61B 6/588

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,705,038 A 11/1987 Sjostrom et al.
5,312,023 A 5/1994 Green et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0 537 570 A2 4/1993
EP 0 647 431 A2 4/1995

(Continued)

OTHER PUBLICATIONS

European Search Report dated Jul. 28, 2011 for EP 11 15 2266.

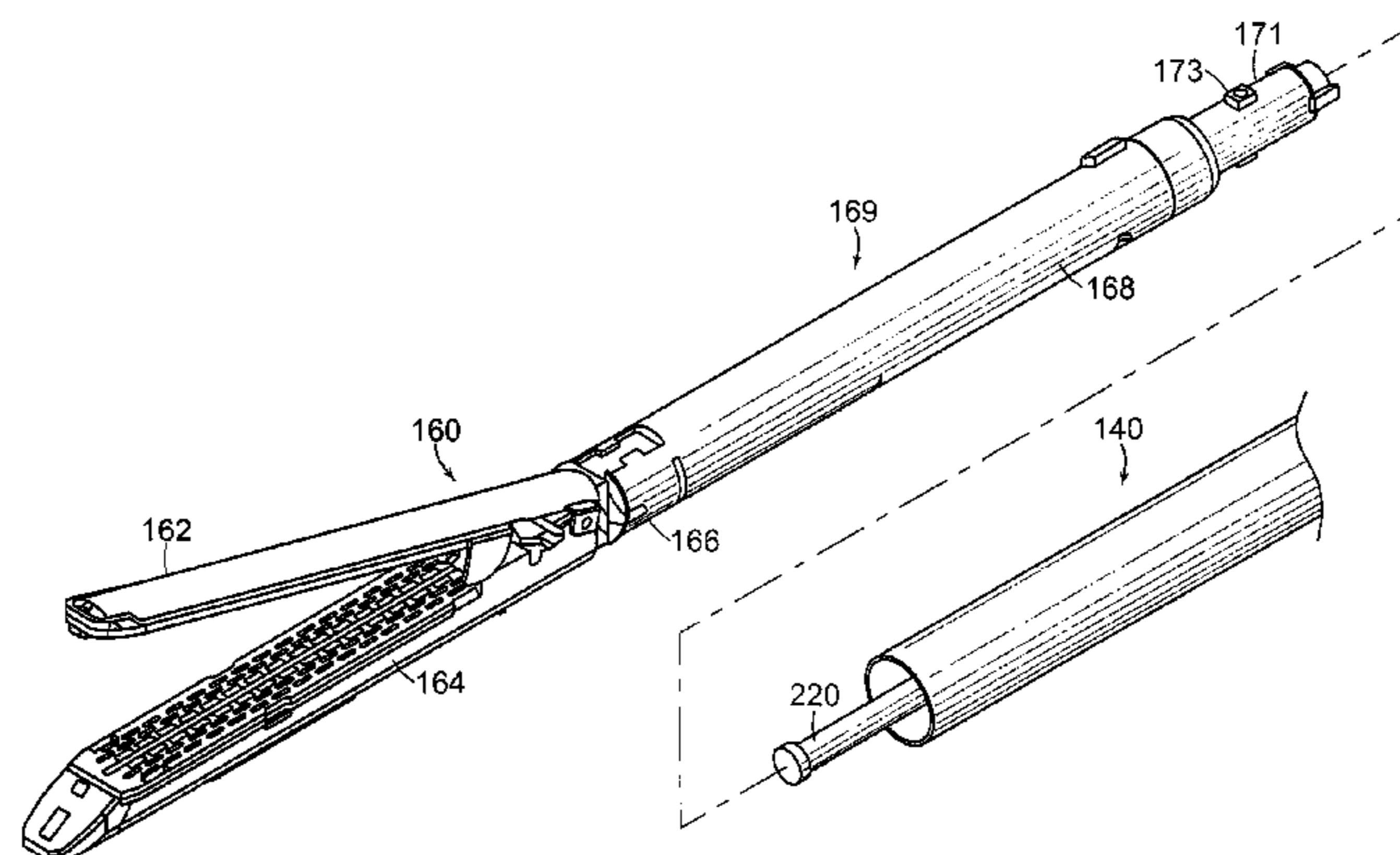
(Continued)

Primary Examiner — Robert Long

(57) **ABSTRACT**

According to one aspect of the present disclosure, a surgical instrument is disclosed. The instrument includes a handle portion, a body portion extending distally from the handle portion and defining a first longitudinal axis and a loading unit. The loading unit includes a tool assembly, the loading adapted to be coupled to the body portion. The instrument also includes a sensor tube movably positioned within the body portion, the sensor tube adapted to engage the loading unit and a load switch coupled to a microcontroller. The load switch is adapted to be actuated by the sensor tube when the sensor tube is engaged by the loading unit being inserted into the body portion.

18 Claims, 8 Drawing Sheets



Related U.S. Application Data

is a continuation of application No. 11/544,203, filed on Oct. 6, 2006, now Pat. No. 7,481,348, and a continuation of application No. 12/189,834, filed on Aug. 12, 2008, now abandoned.

(60) Provisional application No. 61/225,377, filed on Jul. 14, 2009, provisional application No. 60/997,854, filed on Oct. 5, 2007.

(51) **Int. Cl.**

- A61B 17/068* (2006.01)
- A61B 17/072* (2006.01)
- A61B 17/00* (2006.01)
- A61B 17/29* (2006.01)
- A61B 17/32* (2006.01)
- A61B 19/00* (2006.01)

(52) **U.S. Cl.**

- CPC *A61B 2017/00473* (2013.01); *A61B 2017/00482* (2013.01); *A61B 2017/00734* (2013.01); *A61B 2017/2927* (2013.01); *A61B 2017/320052* (2013.01); *A61B 2019/448* (2013.01); *A61B 2017/00725* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,318,221	A	6/1994	Green et al.
5,326,013	A	7/1994	Green et al.
5,364,001	A	11/1994	Bryan
5,487,499	A	1/1996	Sorrentino et al.
5,526,822	A	6/1996	Burbank et al.
5,620,479	A	4/1997	Diederich
5,669,544	A	9/1997	Schulze et al.
5,673,841	A	10/1997	Schulze et al.
5,680,982	A	10/1997	Schulze et al.
5,692,668	A	12/1997	Schulze et al.
5,865,361	A	2/1999	Milliman et al.
5,918,791	A	7/1999	Sorrentino et al.
6,010,054	A	1/2000	Johnson et al.
6,079,606	A	6/2000	Milliman et al.
6,241,139	B1	6/2001	Milliman et al.
6,250,532	B1	6/2001	Green et al.
6,330,965	B1	12/2001	Milliman et al.
6,669,073	B2	12/2003	Milliman et al.
6,830,174	B2	12/2004	Hillstead et al.
6,905,057	B2	6/2005	Swayze et al.
6,918,580	B2 *	7/2005	Obregon et al. 270/58.09
6,953,139	B2	10/2005	Milliman et al.
6,959,852	B2	11/2005	Shelton, IV et al.
6,964,363	B2	11/2005	Wales et al.
6,981,628	B2	1/2006	Wales
7,000,819	B2	2/2006	Swayze et al.
7,055,731	B2	6/2006	Shelton, IV et al.
7,059,508	B2	6/2006	Shelton, IV et al.
7,083,075	B2	8/2006	Swayze et al.
7,111,769	B2	9/2006	Wales et al.
7,128,254	B2	10/2006	Shelton, IV et al.
7,140,528	B2	11/2006	Shelton, IV
7,143,925	B2	12/2006	Shelton, IV et al.
7,143,926	B2	12/2006	Shelton, IV et al.
7,246,734	B2	7/2007	Shelton, IV
7,328,828	B2	2/2008	Ortiz et al.
7,364,061	B2	4/2008	Swayze et al.
7,380,696	B2	6/2008	Shelton, IV et al.
7,404,508	B2	7/2008	Smith et al.
7,416,101	B2	8/2008	Shelton, IV et al.
7,419,080	B2	9/2008	Smith et al.
7,422,139	B2	9/2008	Shelton, IV et al.

7,431,188	B1	10/2008	Marczyk
7,431,189	B2	10/2008	Shelton, IV et al.
7,434,715	B2	10/2008	Shelton, IV et al.
7,441,684	B2	10/2008	Shelton, IV et al.
7,448,525	B2	11/2008	Shelton, IV et al.
7,464,846	B2	12/2008	Shelton, IV et al.
7,464,849	B2	12/2008	Shelton, IV et al.
7,481,348	B2	1/2009	Marczyk
7,487,899	B2	2/2009	Shelton, IV et al.
7,549,563	B2	6/2009	Mather et al.
7,552,854	B2	6/2009	Wixey et al.
7,568,603	B2	8/2009	Shelton, IV et al.
7,641,093	B2	1/2010	Doll et al.
7,644,848	B2	1/2010	Swayze et al.
7,670,334	B2	3/2010	Hueil et al.
7,717,312	B2	5/2010	Beetel
7,721,931	B2	5/2010	Shelton, IV et al.
7,740,159	B2	6/2010	Shelton, IV et al.
7,766,207	B2	8/2010	Mather et al.
7,766,210	B2	8/2010	Shelton, IV et al.
7,770,775	B2	8/2010	Shelton, IV et al.
7,845,537	B2	12/2010	Shelton, IV et al.
7,922,063	B2	4/2011	Zemlok et al.
7,954,682	B2	6/2011	Giordano et al.
8,201,721	B2	6/2012	Zemlok et al.
8,733,614	B2 *	5/2014	Ross et al. 227/179.1
8,800,839	B2 *	8/2014	Beetel 227/175.1
2002/0165541	A1	11/2002	Whitman
2004/0232201	A1	11/2004	Wenchell et al.
2005/0100867	A1	5/2005	Hilscher et al.
2005/0131390	A1	6/2005	Heinrich et al.
2007/0023477	A1	2/2007	Whitman et al.
2007/0084897	A1	4/2007	Shelton et al.
2007/0152802	A1 *	7/2007	Knoll et al. 340/431
2007/0175949	A1	8/2007	Shelton et al.
2007/0175950	A1	8/2007	Shelton et al.
2007/0175951	A1	8/2007	Shelton et al.
2007/0175953	A1	8/2007	Shelton et al.
2007/0175955	A1	8/2007	Shelton et al.
2007/0175964	A1	8/2007	Shelton et al.
2008/0029570	A1	2/2008	Shelton et al.
2008/0029573	A1	2/2008	Shelton et al.
2008/0029574	A1	2/2008	Shelton et al.
2008/0029575	A1	2/2008	Shelton et al.
2009/0090763	A1 *	4/2009	Zemlok et al. 227/175.2
2009/0101694	A1	4/2009	Marczyk
2010/0096435	A1 *	4/2010	Fuchs et al. 227/179.1
2012/0078222	A1 *	3/2012	Smith et al. 604/506

FOREIGN PATENT DOCUMENTS

EP	0 738 501	A1	10/1996
EP	1769754	A1	4/2007
EP	1 813 203	A2	8/2007
WO	03/026511	A1	4/2003
WO	03030743	A2	4/2003

OTHER PUBLICATIONS

European Search Repon dated Apr. 17, 2007 for Corresponding Patent Application EP06026840.
 International Search Report for corresponding PCT Application—PCT/US06/21524—Date of Mailing May 28, 2008 (4 Pages).
 Detemple, P., “Microtechnology in Modem Health Care”, Med Device Technol. 9(9):18-25 (1998).
 European Search Report for corresponding EP 08252703.7 dated Oct. 31, 2008 (3 pages).
 European Search Report dated Feb. 27, 2009 for Corresponding Patent Application 08253184.9.
 European Search Report for Corresponding EP 08251357 dated Sep. 29, 2009 (3 pages).

* cited by examiner

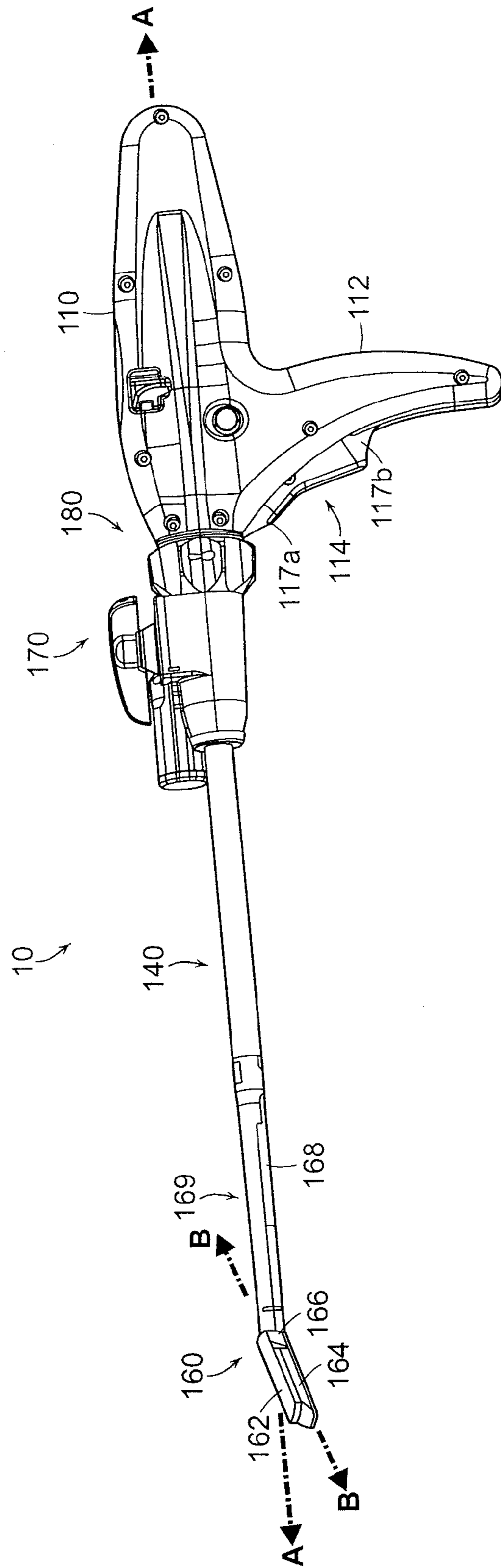


FIG. 1

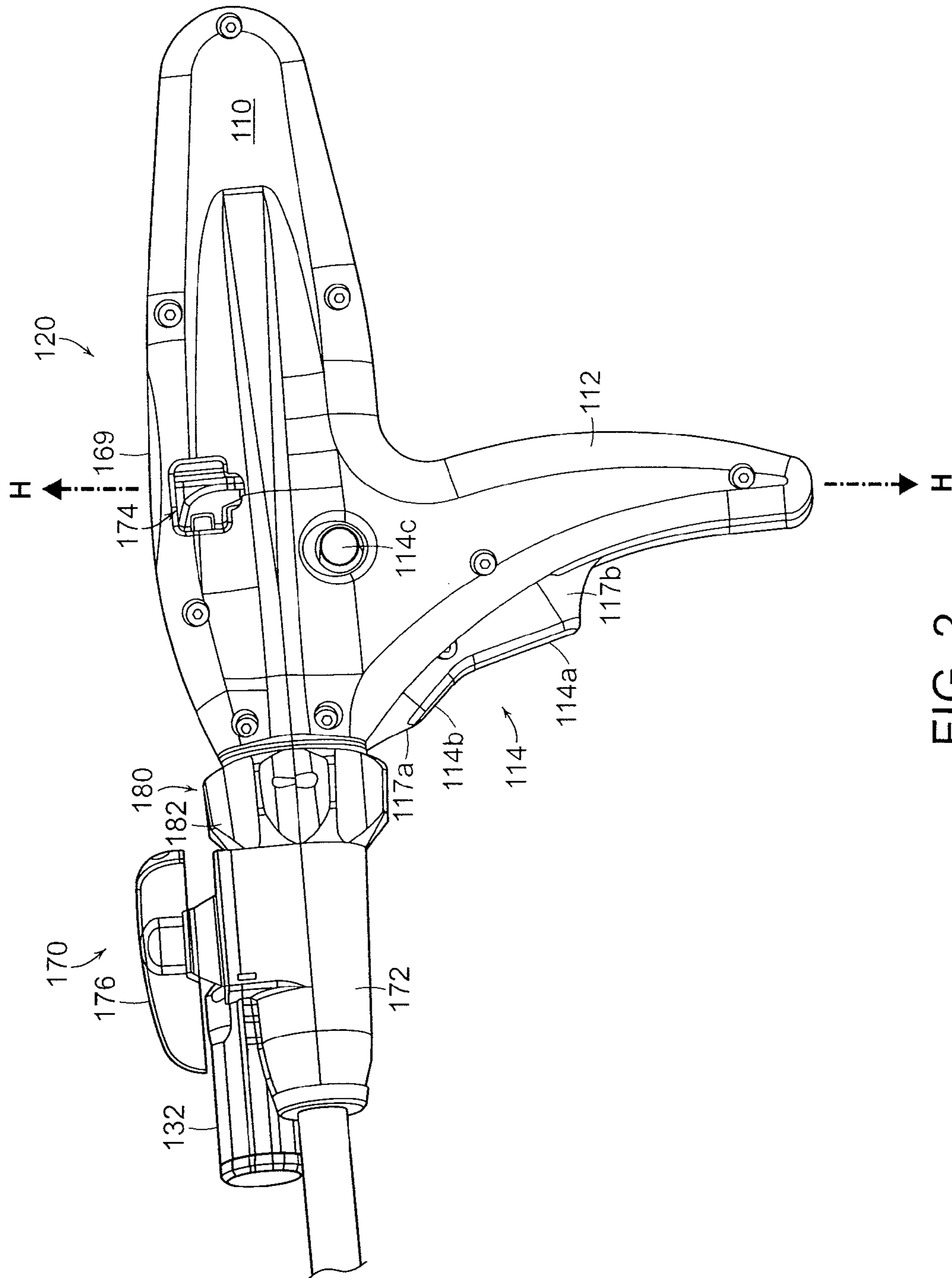


FIG. 2

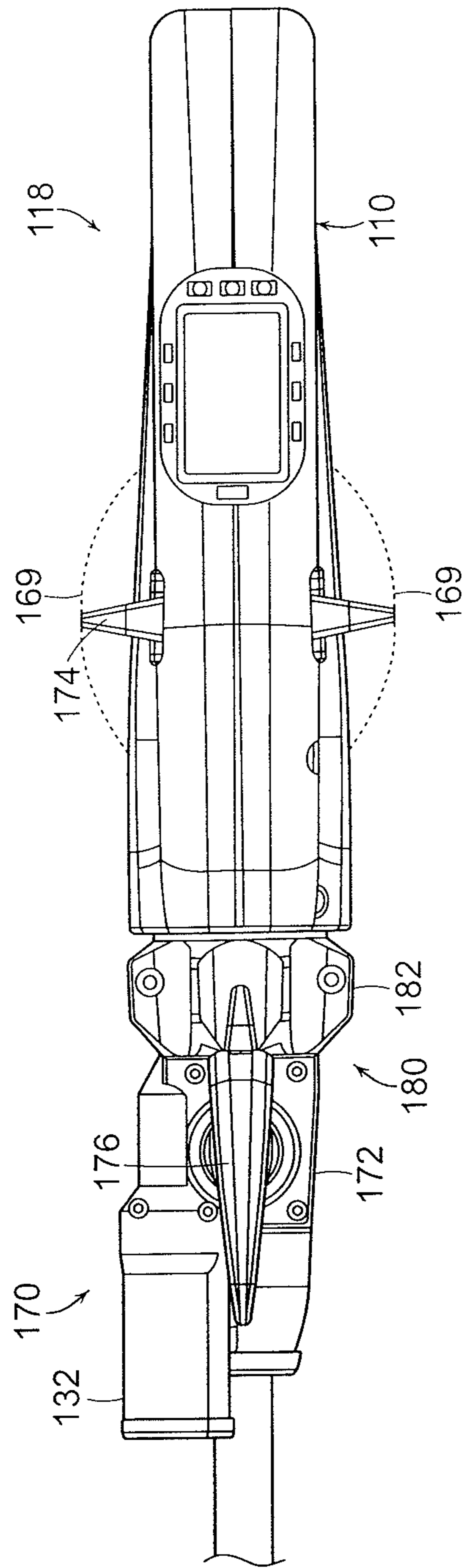


FIG. 3

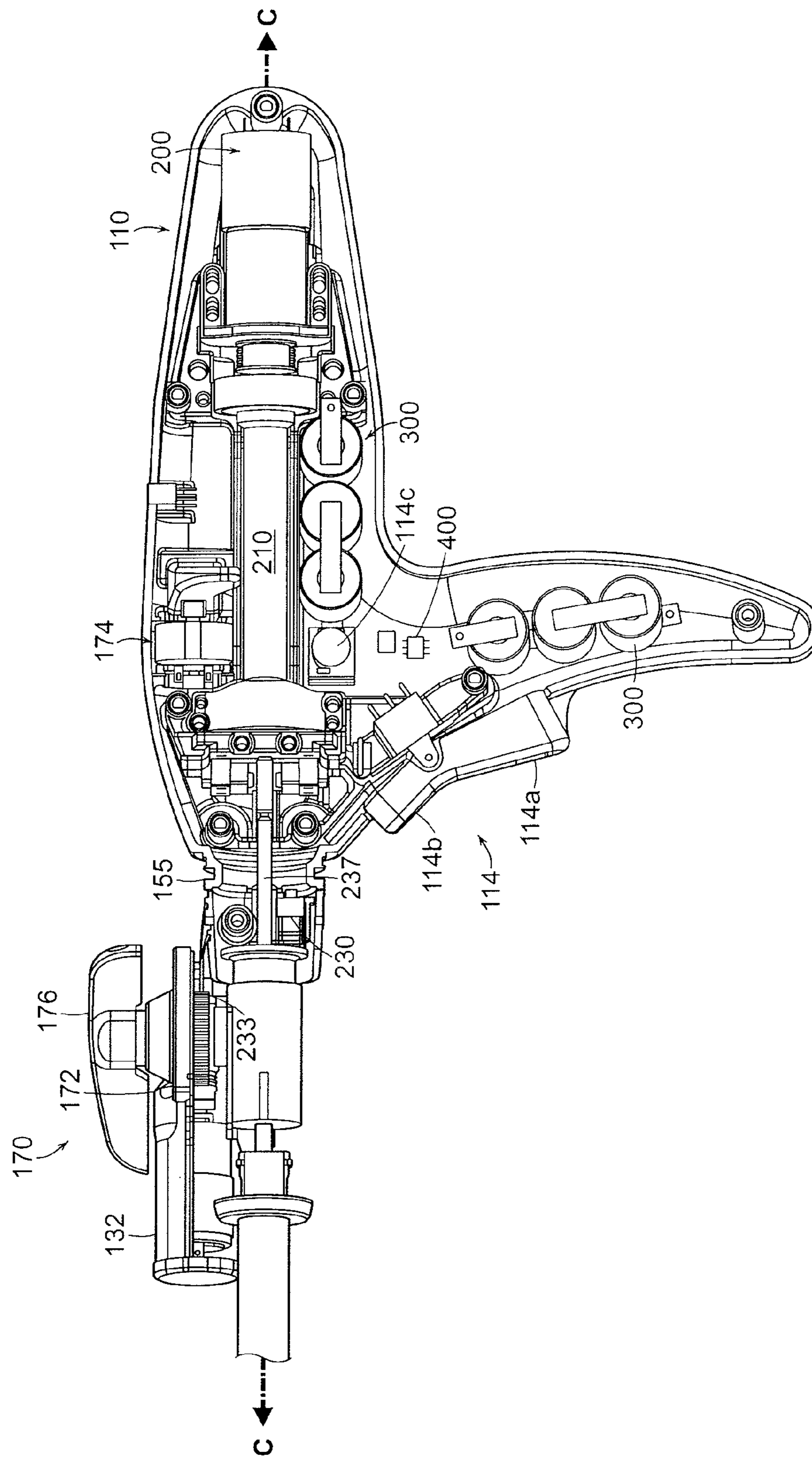


FIG. 4

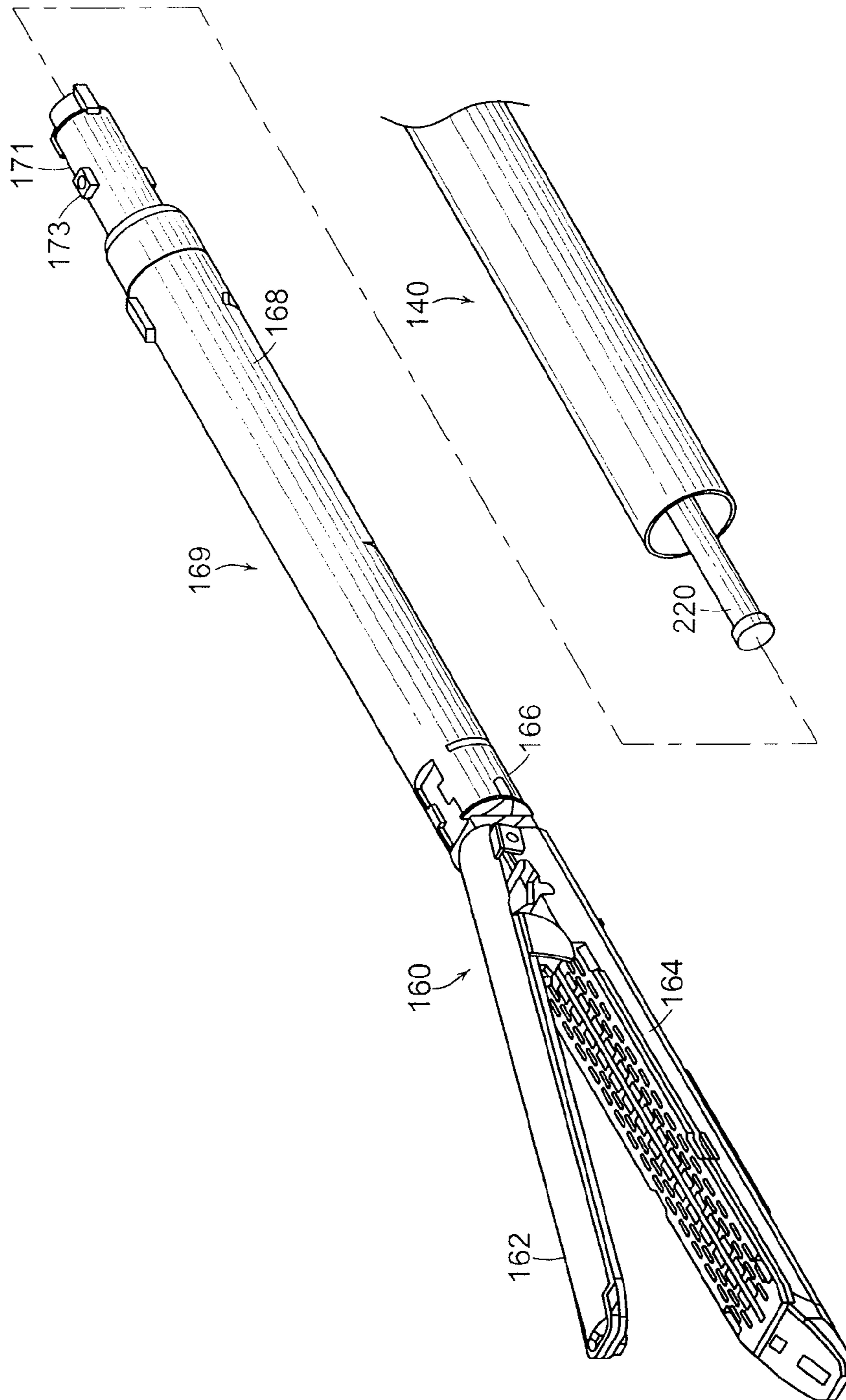


FIG. 5

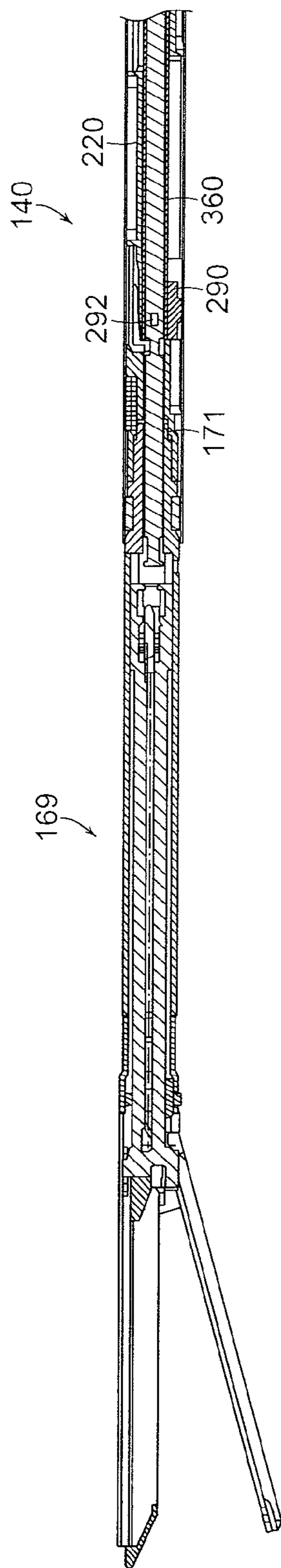


FIG. 6

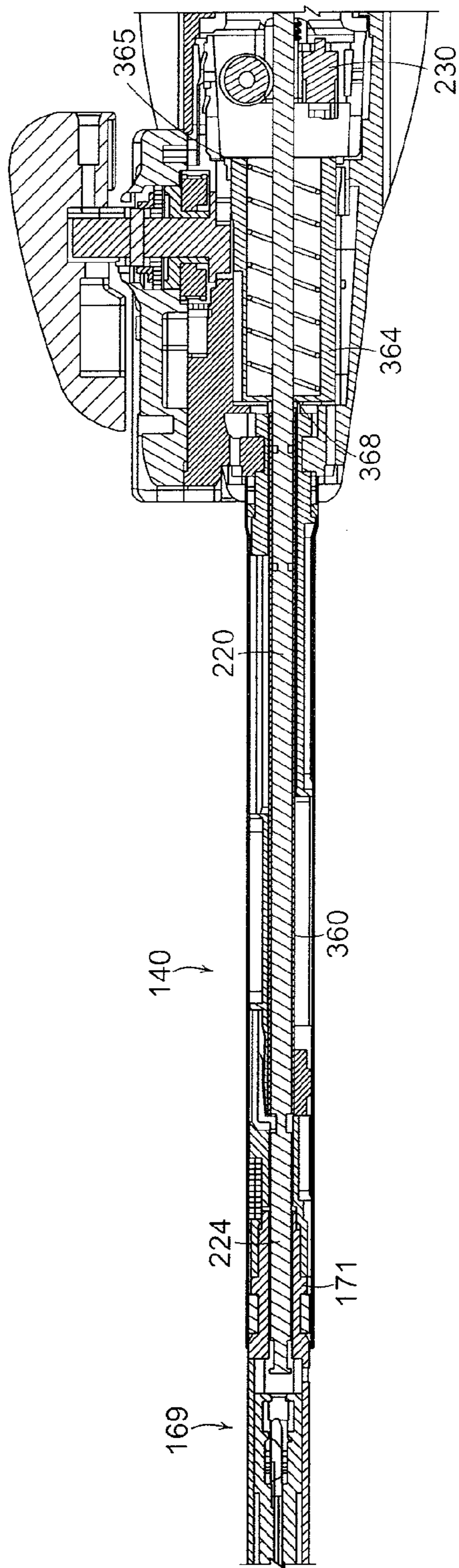


FIG. 7

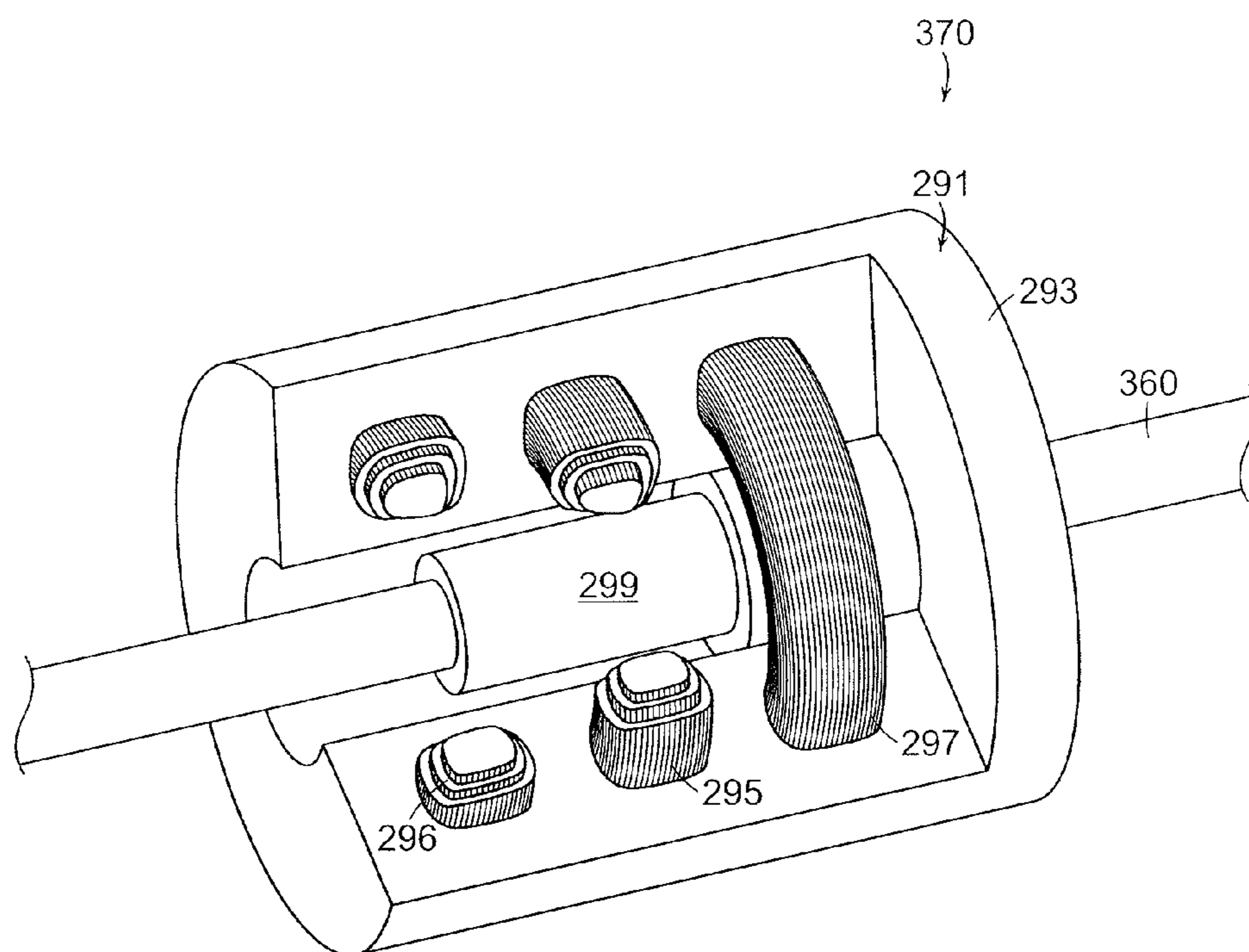


FIG. 8

END EFFECTOR IDENTIFICATION BY MECHANICAL FEATURES

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation application of U.S. application Ser. No. 12/773,176 filed on May 4, 2010, which claims the benefit of and priority to U.S. Provisional Application Ser. No. 61/225,377 filed on Jul. 14, 2009 and is a continuation-in-part application of U.S. application Ser. No. 12/345,167 filed on Dec. 29, 2008 (now U.S. Pat. No. 7,815,090), which is a continuation application of U.S. application Ser. No. 11/544,203 filed on Oct. 6, 2006 (now U.S. Pat. No. 7,481,348). U.S. application Ser. No. 12/773,176 is also a continuation application of U.S. application Ser. No. 12/189,834 filed on Aug. 12, 2008, which claims priority to U.S. Provisional Application Ser. No. 60/997,854 filed on Oct. 5, 2007, the entire contents of all of which are hereby incorporated by reference herein.

BACKGROUND

1. Technical Field

The present disclosure relates to a surgical instrument adapted to be coupled to removable loading units having various end effectors. More particularly, the present disclosure relates to a surgical instrument which includes a mechanism for identifying the type of an end effector mounted to the loading unit.

2. Background of Related Art

Surgical instruments which include a tool assembly mounted on a distal end of a body portion of the surgical instrument for articulation are well known. Typically, such surgical instruments include articulation control mechanisms which allow an operator to remotely articulate the tool assembly in relation to the body portion of a surgical instrument to allow the operator to more easily access, operate on, and/or manipulate tissue.

Such articulating tool assemblies have become desirable, especially in the endoscopic surgical procedures. In an endoscopic surgical procedure, the distal end of a surgical instrument is inserted through a small incision in the body to access a surgical site. Typically, an appropriately sized cannula, e.g., 5 mm, 10 mm, etc., is inserted through the body incision to provide a guide channel for accessing the surgical site.

Current known devices can typically require 10-60 pounds of manual hand force to clamp tissue and deploy and form surgical fasteners in tissue which, over repeated use, can cause a surgeon's hand to become fatigued. Gas powered pneumatic staplers which implant surgical fasteners into tissue are known in the art. Certain of these instruments utilize a pressurized gas supply which connects to a trigger mechanism. The trigger mechanism, when depressed, simply releases pressurized gas to implant a fastener into tissue.

Motor-powered surgical staplers are also known in the art. These include powered surgical staplers having motors which activate staple firing mechanisms. However, these motor powered devices only provide for limited user control of the stapling process. The user can only toggle a single switch and/or button to actuate the motor and applies corresponding torque to the stapler's firing mechanisms. In certain other devices, a controller is used to control the stapler.

There is a continual need for new and improved powered surgical staplers which include various sensors. The sensors provide relevant feedback to feedback controllers which automatically adjust various parameters of the powered sta-

pler in response to sensed feedback signals representative of stapler operation, including articulation and actuation of the tool assemblies.

SUMMARY

According to one aspect of the present disclosure, a surgical instrument is disclosed. The instrument includes a handle portion, a body portion extending distally from the handle portion and defining a first longitudinal axis and a loading unit. The loading unit includes a tool assembly, the loading adapted to be coupled to the body portion. The instrument also includes a sensor tube movably positioned within the body portion, the sensor tube adapted to engage the loading unit and a load switch coupled to a microcontroller. The load switch is adapted to be actuated by the sensor tube when the sensor tube is engaged by the loading unit being inserted into the body portion.

According to another aspect of the present disclosure, a surgical instrument is disclosed. The instrument includes a handle portion and a body portion extending distally from the handle portion and defining a first longitudinal axis. The body portion includes a distal end adapted to releasably engage both articulating and non-articulating loading unit types. The instrument also includes an articulation mechanism configured to articulate an articulating tool assembly coupled to an articulating loading unit and a sensor tube movably positioned within the body portion. The sensor tube is adapted to engage the articulating loading unit. The instrument further includes a load switch coupled to a microcontroller and adapted to be actuated by the sensor tube when the sensor tube is engaged by the articulating loading unit, wherein upon actuation the load switch signals the microprocessor to activate the articulation mechanism.

According to a further embodiment of the present disclosure a surgical instrument is disclosed. The instrument includes a handle portion and a body portion extending distally from the handle portion and defining a first longitudinal axis. The body portion includes a distal end adapted to releasably engage a plurality of loading unit types. The instrument also includes a sensor tube movably positioned within the body portion, the sensor tube adapted to engage each of the plurality of loading unit types and to move a predetermined distance in response thereto; and a variable loading unit sensor adapted to determine a type of a loading unit engaged with the body portion based on the predetermined distance the sensor tube has been displaced.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the subject instrument are described herein with reference to the drawings wherein:

FIG. 1 is a perspective view of a powered surgical instrument according to an embodiment of the present disclosure;

FIG. 2 is a partial enlarged perspective view of the powered surgical instrument of FIG. 1 according to the embodiment of the present disclosure;

FIG. 3 is a partial enlarged plan view of the powered surgical instrument of FIG. 1 according to the embodiment of the present disclosure;

FIG. 4 is a partial sectional view of internal components of the powered surgical instrument of FIG. 1 in accordance with an embodiment of the present disclosure;

FIG. 5 is a perspective view of a loading unit according to one embodiment of the present disclosure;

FIG. 6 is a partial sectional view of internal components of the loading unit and the powered surgical instrument of FIG. 1 according to the embodiment of the present disclosure;

FIG. 7 is a partial sectional view of internal components of the loading unit and the powered surgical instrument of FIG. 1 according to the embodiment of the present disclosure; and

FIG. 8 is a partial perspective sectional view of variable loading unit sensor according to the embodiment of the present disclosure.

DETAILED DESCRIPTION

Embodiments of the presently disclosed powered surgical instrument are now described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views. As used herein the term “distal” refers to that portion of the powered surgical instrument, or component thereof, farther from the user while the term “proximal” refers to that portion of the powered surgical instrument or component thereof, closer to the user.

A powered surgical instrument, e.g., a surgical stapler, in accordance with the present disclosure is referred to in the figures as reference numeral 10. Referring initially to FIG. 1, powered surgical instrument 10 includes a housing 110, a body portion, such as, for example, an endoscopic portion 140 defining a first longitudinal axis A-A extending there-through, and a loading unit 169. Loading unit 169 includes a proximal body portion 168 and an articulating tool assembly (e.g., end effector 160), defining a second longitudinal axis B-B extending therethrough. Endoscopic portion 140 extends distally from housing 110 and proximal body portion 168 of loading unit 169 is disposed adjacent a distal portion of endoscopic portion 140. In an embodiment, the components of the housing 110 are sealed against infiltration of particulate and/or fluid contamination and help prevent damage of the components by sterilization processes.

According to an embodiment of the present disclosure, end effector 160 includes a first jaw member having one or more surgical fasteners (e.g., cartridge assembly 164) and a second opposing jaw member including an anvil portion for deploying and forming the surgical fasteners (e.g., an anvil assembly 162). In certain embodiments, the staples are housed in cartridge assembly 164 to apply linear rows of staples to body tissue either in simultaneous or sequential manner. Either one or both of the anvil assembly 162 and the cartridge assembly 164 are movable in relation to one another between an open position, in which the anvil assembly 162 is spaced from cartridge assembly 164, and an approximated or clamped position, in which the anvil assembly 162 is in juxtaposed alignment with cartridge assembly 164.

It is further envisioned that end effector 160 is attached to a mounting portion 166, which is pivotably attached to proximal body portion 168. Proximal body portion 168 may be integral with endoscopic portion 140 of powered surgical instrument 10, or may be removably attached to the instrument 10 such that loading unit 169 is in the form of a replaceable, disposable loading unit (DLU) or single use loading unit (SULU). In certain embodiments, the reusable portion may be configured for sterilization and re-use in a subsequent surgical procedure.

A proximal end of proximal body portion 168 of loading unit 169 may be connectable to endoscopic portion 140 through a bayonet connection. It is envisioned that a distal end of proximal body portion 168 of loading unit 169 has an articulation link connected to mounting portion 166 of the loading unit 169 and the articulation link is connected to a

linkage rod so that the end effector 160 is articulated as the linkage rod is translated in the distal-proximal direction along first longitudinal axis A-A as discussed in more detail below. Other means of connecting end effector 160 to endoscopic portion 140 to allow articulation may be used, such as a flexible tube or a tube comprising a plurality of pivotable members.

The loading unit 169 may incorporate or be configured to incorporate various end effectors, such as vessel sealing devices, linear stapling devices, circular stapling devices, cutters, graspers, etc. Such end effectors may be coupled to endoscopic portion 140 of powered surgical instrument 10. An intermediate flexible shaft may be included between handle portion 112 and loading unit. It is envisioned that the incorporation of a flexible shaft may facilitate access to and/or within certain areas of the body.

With reference to FIGS. 1 and 2, an enlarged view of the housing 110 is illustrated according to an embodiment of the present disclosure. In the illustrated embodiment, housing 110 includes a handle portion 112 having a main drive switch 114 disposed thereon. The switch 114 may include first and second switches 114a and 114b formed together as a toggle switch. The handle portion 112, which defines a handle axis H-H, is configured to be grasped by fingers of a user. The handle portion 112 has an ergonomic shape providing ample palm grip leverage which helps prevent the handle portion 112 from being squeezed out of the user's hand during operation. Each switch 114a and 114b is shown as being disposed at a suitable location on handle portion 112 to facilitate its depression by a user's finger or fingers.

Additionally, and with reference to FIGS. 1 and 2, switches 114a, 114b may be used for starting and/or stopping movement of drive motor 200 (FIG. 4). In one embodiment, the switch 114a is configured to activate the drive motor 200 in a first direction to advance firing rod (not explicitly shown) in a distal direction thereby approximating the anvil and the cartridge assemblies 162 and 164. Conversely, the switch 114b may be configured to retract the firing rod to open the anvil and cartridge assemblies 162 and 164 by activating the drive motor 200 in a reverse direction. The retraction mode initiates a mechanical lock out, preventing further progression of stapling and cutting by the loading unit 169. The toggle has a first position for activating switch 114a, a second position for activating switch 114b, and a neutral position between the first and second positions.

The housing 110, in particular the handle portion 112, includes switch shields 117a and 117b. The switch shields 117a and 117b may have a rib-like shape surrounding the bottom portion of the switch 114a and the top portion of the switch 114b, respectively. The switch shield 117a and 117b prevent accidental activation of the switch 114. Further, the switches 114a and 114b have high tactile feedback requiring increased pressure for activation.

In one embodiment, the switches 114a and 114b are configured as multi-speed (e.g., two or more), incremental or variable speed switches which control the speed of the drive motor 200 and the firing rod in a non-linear manner. For example, switches 114a, 114b can be pressure-sensitive. This type of control interface allows for gradual increase in the rate of speed of the drive components from a slower and more precise mode to a faster operation. To prevent accidental activation of retraction, the switch 114b may be disconnected electronically until a fail safe switch 114c is pressed.

The switches 114a and 114b are coupled to a non-linear speed control circuit which can be implemented as a voltage regulation circuit, a variable resistance circuit, or a microelectronic pulse width modulation circuit. The switches 114a and

144b may interface with the control circuit by displacing or actuating variable control devices, such as rheostatic devices, multiple position switch circuit, linear and/or rotary variable displacement transducers, linear and/or rotary potentiometers, optical encoders, ferromagnetic sensors, and Hall Effect sensors. This allows the switches **114a** and **114b** to operate the drive motor **200** in multiple speed modes, such as gradually increasing the speed of the drive motor **200** either incrementally or gradually depending on the type of the control circuit being used, based on the depression of the switches **114a** and **114b**.

FIGS. 2-4 illustrate an articulation mechanism **170**, including an articulation housing **172**, a powered articulation switch **174**, an articulation motor **132** and a manual articulation knob **176**. Translation of the powered articulation switch **174** activates the articulation motor **132** which then actuates an articulation gear **233** of the articulation mechanism **170** as shown in FIG. 4. Pivoting of the manual articulation knob **176** bypasses the articulation motor **132** to actuate the articulation mechanism **170**. The manual articulation knob **176** also provides an indication of the angulation of the end effector **160** with respect to longitudinal axis A-A. Actuation of articulation mechanism **170** causes the end effector **160** to move from its first position, where longitudinal axis B-B is substantially aligned with longitudinal axis A-A, towards a position in which longitudinal axis B-B is disposed at an angle to longitudinal axis A-A. The powered articulation switch **174** may also incorporate similar non-linear speed controls as the clamping mechanism. These can be controlled by the switches **114a** and **114b**.

With reference to FIGS. 2 and 3, the housing **110** includes switch shields **167** having a wing-like shape and extending from the top surface of the housing **110** over the switch **174**. The switch shields **167** prevent accidental activation of the switch **174** and require the user to reach below the shield **167** in order to activate the articulation mechanism **170**.

Additionally, articulation housing **172** and manual articulation knob **176** are mounted to a rotating housing assembly **180**. Rotation of a rotation knob **182** about first longitudinal axis A-A causes housing assembly **180** as well as articulation housing **172** and manual articulation knob **176** to rotate about first longitudinal axis A-A, and thus causes corresponding rotation of distal portion **224** of firing rod **220** and end effector **160** about first longitudinal axis A-A. The articulation mechanism **170** is electro-mechanically coupled to one or more conductive rings that are disposed on a housing nose assembly **155** (FIG. 4). The conductive rings may be soldered and/or crimped onto the nose assembly **155** and are in electrical contact with a power source **300** thereby providing electrical power to the articulation mechanism **170**. The nose assembly **155** may be modular and may be attached to the housing **110** during assembly to allow for easier soldering and/or crimping of the rings. The articulation mechanism **170** may include one or more brush and/or spring loaded contacts in contact with the conductive rings such that as the housing assembly **180** is rotated along with the articulation housing **172** the articulation mechanism **170** is in continuous contact with the conductive rings thereby receiving electrical power from the power source **300**.

Further details of articulation housing **172**, powered articulation switch **174**, manual articulation knob **176** and providing articulation to end effector **160** are described in detail in commonly-owned U.S. Pat. No. 7,431,188, the contents of which are hereby incorporated by reference in their entirety. It is envisioned that any combinations of limit switches, proximity sensors (e.g., optical and/or ferromagnetic), linear variable displacement transducers and shaft encoders which may

be disposed within housing **110**, may be utilized to control and/or record an articulation angle of end effector **160** and/or position of the firing rod **220**.

As shown in FIG. 4, the instrument **10** also includes a microcontroller **400** electrically coupled to the motor **200** and various sensors disposed in the instrument **10**. The sensors detect various operating parameters of the instrument **10** (e.g., linear speed, rotation speed, articulation position, temperature, battery charge, and the like), which are then reported to the microcontroller **400**. The microcontroller **400** may then respond accordingly to the measured operating parameters (e.g., adjust the speed of the motor **200**, control articulation angle, shut-off the power supply, report error conditions, etc.).

With continued reference to FIG. 4, a load switch **230** is disposed within the articulation housing **172**. The switch **230** is connected in series with the switch **114**, preventing activation of the instrument **10** unless the loading unit **169** is properly loaded into the instrument **10**. If the loading unit **169** is not loaded into the instrument **10**, the main power switch (e.g., switch **114**) is open, thereby preventing use of any electronic or electric components of the instrument **10**. This also prevents any possible current draw from the power source **300** allowing the power source **300** to maintain a maximum potential over its specified shelf life.

Thus, the switch **230** acts as a so-called "lock-out" switch which prevents false activation of the instrument **10** since the switch **230** is inaccessible to external manipulation and can only be activated by the insertion of the loading unit **169**. The switch **230** is activated by displacement of a plunger or sensor tube **360** as the loading unit **169** is inserted into the endoscopic portion **140**. Once the switch **230** is activated, the power from the power source **300** is supplied to the electronic components (e.g., sensors, microcontroller **400**, etc.) of the instrument **10** providing the user with access to a user interface and other inputs/outputs.

As shown in FIGS. 5-7, the endoscopic portion **140** includes the sensor tube **360** (FIG. 6) therein disposed around the firing rod **220**. The firing rod **220** passes through an opening **368** at a distal end of a sensor cap **364** (FIG. 7). The sensor cap **364** includes a spring **365** and abuts the switch **230**. The sensor cap **364** is biased against the sensor tube **360**, which is in contact with the distal end of the sensor cap **364**.

As shown in FIGS. 5 and 6, when the loading unit **169** is loaded into the endoscopic portion **140**, the proximal portion **171** abuts the sensor tube **360**, which displaces the sensor tube **360** in a proximal direction. With reference to FIG. 7, the sensor tube **360** then pushes on the sensor cap **364** in the proximal direction, which then compresses the spring **365** and activates the switch **230** denoting that the loading unit **169** has been properly inserted. Once the loading unit **169** is inserted into the endoscopic portion, the switch **230** also determines whether the loading unit **169** is loaded correctly based on the position thereof. If the loading unit **169** is improperly loaded, the switch **114** is not activated and an error code is relayed to the user.

In another embodiment, the switch **230** may be adapted to sense the type of a disposable loading unit **169** (e.g., articulating vs. non-articulating) engaged with the endoscopic portion **140**. When a non-articulating loading unit is used, the sensor tube **360** is not engaged and the sensor cap **364** does not activate the switch **230**. The switch **230** may still allow for operation of the instrument **10**, but prevent operation of the articulation mechanism **170**. When an articulating loading unit **169** is used, the sensor tube **360** is engaged and the sensor cap **364** activates the switch **230**. The switch **230** allows for operating of the instrument **10** including the articulation

mechanism 170. The articulating and non-articulating loading units may be distinguished by a protrusion 173 (FIG. 5) or extended insertion tip (not explicitly shown) that when present, is configured to engage the sensor tube 360. In other words, non-articulating loading units do not have a protrusion 173 for engaging the sensor tube 360 and thus do not activate the switch 230, whereas the articulating loading units 169 include the protrusion 173 and can thus enable operation of the articulation mechanism 169. Thus, the sensor tube 360 is movable to a first position or is not moved at all in response to engagement with a non-articulating loading unit and is movable to a second position in response to engagement of an articulating loading unit 169, in response to which sensor tube 360 actuates the switch 230. The switch 230 is coupled to the microcontroller 400 and is configured to transmit the sensor signal reflective of the sensor tube 360 being engaged by the articulating loading unit 169. The microcontroller 400 then determines that the loading unit 169 is articulating and activates the articulation mechanism 170. Another type of sensing mechanism is described in a commonly-owned U.S. Pat. No. 5,865,361 entitled "Surgical Stapling Apparatus" the contents of which are hereby incorporated herein in their entirety by reference.

With reference to FIG. 6, the instrument 10 may also include a variable loading unit sensor 370. The loading unit sensor 370 includes a linear potentiometer 290 disposed within the endoscopic portion 140. The linear potentiometer 290 is electrically coupled to a contact 292 disposed on the sensor tube 360. As the loading unit 169 is inserted into the endoscopic portion 140, the sensor tube 360 is moved in the proximal direction. As a result of the movement of the sensor tube 360, the contact 292 slides along the surface of the linear potentiometer 290.

In another embodiment shown in FIG. 8, the variable loading unit sensor 370 may also include a linear variable differential transducer (LVDT) 291 disposed about the sensor tube 360. The LVDT 291 includes a transformer 293 having three solenoidal coils arranged about the sensor tube 360, with a center coil 295 being the primary, and the outer coils 296 and 297 being the secondaries. A cylindrical ferromagnetic core 299 may be attached to the sensor tube 360. To measure the displacement of the sensor tube 360, an alternating current is driven through the center coil 295, causing a voltage to be induced in each secondary proportional. As the sensor tube 360 moves, these mutual inductances change due to the shift in the magnetic field brought about by the magnetic core 299 causing the voltages induced in the outer coils 296 and 297 to change. The coils 295, 296 and 297 may be connected in reverse series, so that the output voltage is the difference between the two voltages of the outer coils 296 and 297. When the core 299 is in its central position (e.g., equidistant between the outer coils 296 and 297) equal but opposite voltages are induced in outer coils 296 and 297, so the output voltage is zero.

The variable loading unit sensor 370 is coupled to the microcontroller 400, which is configured to determine the type of the loading unit 169 coupled to the instrument 10 based on the signal from the variable loading unit sensor 370. If the sensor tube 360 is not engaged, such as when the loading unit 169 is not properly inserted, then the variable loading unit sensor 370 is not actuated and the microcontroller 400 does not activate the instrument 10. It is envisioned that various types of loading units 169 may include protrusion 173 and/or extended insertion tips for engaging the sensor tube 360. A non-articulating loading unit may include a protrusion 173 of a first type, while an articulating loading unit 169 may have a protrusion 173 of a second type that is of

different dimensions than the first type protrusion 173. In other words, the protrusion 173 of one loading unit 169 is either longer or shorter than the protrusion 173 on another type of loading unit 169. As a result, when inserted, each type of the loading unit 169 engages the sensor tube 360 by a predetermined distance. As a result, the variable loading unit sensor 370 then transmits the corresponding sensor signal corresponding to the displacement of the sensor tube 360 to the microprocessor 400, which then determines the type of the loading unit 169 based thereon. The microcontroller 400 may then activate the articulation mechanism 170 when the loading unit 169 is of articulating type.

The microcontroller 400 may then adjust operating parameters of the instrument 10 to match the inserted loading unit 169 based on the displacement of the sensor tube 360. The adjustable parameters may include firing stroke length, firing speed, degree of articulation and the like. As discussed above, the microcontroller may also prevent actuation of the instrument 10 until the loading unit 169 was loaded into the instrument 10. In another embodiment, the variable loading unit sensor 370 may be disposed along any of the moving sensor parts, such as the sensor tube 360 and the sensor cap 364.

It will be understood that various modifications may be made to the embodiments shown herein. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Although specific features of the powered surgical instrument are shown in some of the drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the aspects of the present disclosure. Other embodiments will occur to those skilled in the art and are within the following claims.

What is claimed:

1. A surgical instrument configured for coupling with a plurality of loading unit types, the surgical instrument comprising:

a handle portion;

a body portion coupled to the handle portion;

a sensor tube movably disposed within the body portion, the sensor tube configured to engage a loading unit, wherein the sensor tube includes a contact supported thereon; and

a potentiometer disposed within the body portion and electrically and slidably coupled to the contact, wherein the potentiometer is configured to output a sensor signal corresponding to a predetermined distance traveled by the contact relative to the potentiometer upon engagement of a loading unit with the sensor tube.

2. The surgical instrument according to claim 1, further comprising a microcontroller coupled to the potentiometer and configured to determine a type of a loading unit engaged with the body portion based on the sensor signal.

3. The surgical instrument according to claim 2, wherein the potentiometer is configured to transmit the sensor signal to the microcontroller.

4. The surgical instrument according to claim 2, wherein the microcontroller is configured to adjust at least one operating parameter of the surgical instrument based on a type of a loading unit engaged with the body portion.

5. The surgical instrument according to claim 4, wherein the at least one operating parameter is selected from the group consisting of firing stroke length, firing speed, and degree of articulation of a loading unit.

6. A surgical instrument, comprising:

a handle portion;

9

a body portion coupled to the handle portion, the body portion having a distal portion configured to releasably engage a plurality of types of loading units;

a sensor tube including a magnetic member, the sensor tube being movable relative to the body portion and configured to engage a plurality of types of loading units; and
 a magnetic sensor disposed about the magnetic member and configured to be actuated by the magnetic member when the sensor tube is engaged by a loading unit, wherein upon actuation, the magnetic sensor outputs a sensor signal reflective of the sensor tube being engaged with a loading unit.

7. The surgical instrument according to claim 6, wherein the magnetic sensor is linear variable differential transducer including a transformer disposed about the sensor tube.

8. The surgical instrument according to claim 7, wherein the transformer includes a plurality of coils disposed about the sensor tube.

9. The surgical instrument according to claim 6, further comprising a microcontroller configured to determine a type of a loading unit engaged with the body portion based on the sensor signal.

10. The surgical instrument according to claim 9, wherein upon actuation, the magnetic sensor signals the microcontroller to activate the surgical instrument.

11. The surgical instrument according to claim 10, wherein the sensor tube is engageable only by a loading unit including an articulating tool assembly.

12. The surgical instrument according to claim 11, further including an articulation mechanism configured to articulate an articulating tool assembly.

10

13. The surgical instrument according to claim 12, wherein upon engagement by a loading unit including an articulating tool assembly, the microcontroller enables the articulation mechanism.

14. The surgical instrument according to claim 6, wherein the sensor signal corresponds to a predetermined distance traveled by the magnetic member relative to the magnetic sensor upon engagement of a loading unit with the sensor tube.

15. A surgical instrument, comprising:
 a handle portion;
 a body portion coupled to the handle portion, the body portion having a distal portion configured to releasably engage a plurality of loading unit types;
 a sensor tube including a magnetic member disposed within the body portion, the sensor tube being configured to engage a plurality of loading unit types, wherein the sensor tube moves a predetermined distance in response to engaging a loading unit; and
 a transformer disposed about the sensor tube, wherein the transformer is configured to generate a sensor signal corresponding to a predetermined distance the sensor tube is displaced by a loading unit.

16. The surgical instrument according to claim 15, wherein the transformer includes a plurality of coils disposed about the sensor tube.

17. The surgical instrument according to claim 16, wherein the plurality of coils is connected in reverse series.

18. The surgical instrument according to 15, further including a microcontroller configured to determine a type of a loading unit engaged with the body portion based on the sensor signal.

* * * * *